

Sensing Clouds via Spacecraft Radio Occultation Observations

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The presence of clouds dramatically alters the opacity and radiative transfer within Earth's atmosphere at both short and long wavelengths. Knowledge of cloud top and base is needed to estimate the Outgoing Long wave Radiation (OLR) to space and the net radiation at the surface from a given atmospheric profile. Satellite observations are required to provide the global perspective needed for climate. Cloud top pressure can be determined to some accuracy from spaceborne radiance measurements when cloud opacities are sufficiently large and cloud top temperatures are sufficiently low to readily them from the surface. Cloud base is particularly difficult to determine from space. The relatively small sensitivity of long wavelengths must be used to penetrate the clouds while at the same time providing sufficient sensitivity to detect the cloud base.

We are studying the indirect sensitivity of radio occultation observations to clouds through their impact on the refractivity structure. The tradewind inversion is an excellent example where a very sharp refractivity structure coincides with the top of the tradewind cumulus and stratus clouds. In general, any cloud with sufficient IR opacity will have large transmissivity gradient at cloud top (base) which will result in large cooling (heating) which will create a thermal inversion at cloud top (base). Both liquid and ice clouds can reach this critical opacity. The thermal inversion and sharp change in specific humidity will cause a sharp change in the refractivity gradient which can be identified in the radio occultation results, particularly the signal amplitude. The occultations yield very accurate information on the height of such features. The heating at cloud base drives convection causing the air to follow a moist adiabat within the cloud which further helps constrain the interpretation of the observations. The upward expansion of such opaque clouds due to convection may be an important mechanism supplying moisture into the upper troposphere.

We will present simulations using high resolution radiosondes from field campaigns representing the expected signatures of such features. We will also present initial results of comparisons between GPS observations and GOES-derived cloud tops to assess the utility of this concept.